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## ABSTRACT

The research component in the natural sciences does not have to be changed. Ninety-three percent of the students surveyed by Ann Heiss for her book "The Challenge to the Graduate Schools" felt that the research component of the natural sciences contributed to their scientific development, and 85 percent felt that it was intellectually stimulating. Eighty-eight percent of the faculty surveyed felt that dissertation research component should remain unchanged. In contrast, only 43 percent of the graduate students in English thought that research contributed to their development. This happy condition in the natural sciences is due to the mutual dependence of professor and student. The student does his first research on a professor's problem and does not do his own research until his last year. This seems to work to both the professor's and student's benefit. In the social sciences and humanities, students tend to begin on their own and professors tend to view their role as teachers and advisors as a duty role. There are also differences within the natural sciences. The chemist tends to get his doctorate in 4 years, and often takes a 2-year postdoctorate. The physicist takes generally 6 years for his doctorate under the same professor. The 4- and 2- year schedule provides for more flexibility and greater self-selection of the students. (AF)

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RESEARCH COMPONENT - NATURAL SCIENCES\*

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& WELFARE

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DR. DONALD COOKE: As some of you know I have a tendency to be an iconoclast and Boyd, when he asked me to speak, probably had the feeling, "Well, Don Cooke will say something to make everybody mad," and I am afraid I am going to disappoint Boyd because when I look at the research component of the natural sciences I think my own evaluation is that we have no need for any fundamental changes. I would like to try to defend that particular point of view.

\*Address presented at the 10th Annual Meeting of the Council of Graduate Schools in the United States, Miami Beach, Florida, Thursday, December 3, 1970.

Obviously being a natural scientist myself and a chemist in particular, I may be accused of prejudice.

But how is it that I can make such an odd evaluation in these days of turmoil and change and so many things happening, re-evaluation of programs? Well, I guess the latest piece of evidence comes from a new book by Ann Heiss, "The Challenge to the Graduate Schools."

In writing that book she made a survey of some 3,000 students in ten universities and some hundreds of faculty members. There is no question that the book in general, and the results of the study in particular, are a long litany of student discontent.

However, when you look at the fine structure of the study it turns out that the natural sciences stand out relatively as a bright spot, particularly when we are talking about the research component.

If my charge were broader, rather than the research component of the Ph.D., I could find much to be iconoclastic about because I think there is much that should be changed in graduate education, much that is wrong with the subject.

But let's look at how the students and

faculty answered questions in the survey about the research component of the Ph.D. program, again limited to natural sciences.

As to students, 85 per cent of the students felt that the research component was intellectually stimulating; 93 per cent felt that it contributed to their scientific development. They are pretty high numbers these days, considering what graduate students are about.

I am not saying that the book gave no complaints of students in the natural sciences, but they were generally related to other things than the research component; teaching assistantship conditions and stipends and many other things. But the research component seemed to be accepted by everybody.

The faculty--again I am talking about the natural sciences--in their answering the question, 88 per cent felt that the dissertation research components should remain unchanged. In these days of turmoil and student-faculty polarization this is a remarkably unanimous consensus. Too, one would have to be thoroughly brave to say we are going to change all that.

Parenthetically I might add for my chemistry colleagues a quote from Ann Heiss' book. After reviewing

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all the student questionnaires she concludes: "From responses of the students, the doctoral program in chemistry is apparently the ideal approach." (Laughter)

One might ask the question of why it comes out this way. And there are truly remarkable differences between the various areas when it comes to student evaluation of their dissertation research. If I remember correctly, instead of 93 per cent of the students in sciences replying that they thought the research contributed to their development, the figure in English, I believe, was 43 per cent. That's a big difference. There are striking differences across the areas and I might try to speculate a bit on why this is.

Is there a lesson here, say, for the other areas? I think that the fact that the natural sciences seem to work relatively so much better is a happy confluence of two basic conditions that apply, I am afraid, only to the natural sciences.

First, beginning graduate students rarely have the maturity to pick a particular research problem. He often has an option of the sort of things that he would like to do, but it is the professor's problem. So the students need the professor.

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Secondly, in the natural sciences, the professor needs the student. He needs the student to maintain his research effort and his reputation depends upon the student. So they both have substantial need for each other and this happy marriage of roles and ambitions probably explains the relative lack of discontent for students in the natural sciences; again, on a research component.

I would like to emphasize they have other complaints.

Of course, one could argue that this is a poor way to train students, that all you are doing is using them as a pair of hands, and I suppose to some degree this is true, but there is another side to the coin. In any well run program students in the natural sciences gradually develop into independent investigators and most scientists know that the student in his last year of his research is normally completely doing it on his own with a small input from the professor and that is, of course, when we give him his degree.

Now if we were to change that system, say to allow students to pick their own problems and be more like the other areas, then one can give some idealized

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arguments for this; let him develop his own imagination, let him think about the problems. The only argument I would have against that is the problems would be trivial and the advancement of American science would come to a halt.

Now in the social sciences and humanities the situation between the professor and the student is very different. Normally students will choose their own problems; it is his responsibility, hopefully he gets some help from his professor. But what he does in his own research, in his own publication has no effect on the professor's reputation, or at best only indirectly. The professor's name is rarely on the publication. And given these two different roles, I think most professors in social sciences and humanities look at their role as one of a duty role. They are professors, they are supposed to teach students, they get paid for teaching students and directing research and scholarship of graduate students, and he accepts that duty. But neither one is very dependent on the other.

The students frequently, after they pass their admission to candidacy examination go off somewhere else totally independently of a professor and write the

thesis, and as all of you know, every once in a while you get a thesis in the mail, a student that you hadn't heard of for five years and the professor didn't even know he was alive.

I might add, too, that the situation in mathematics and physical science theory is not unlike, say, the social science professor. I think students in mathematics contribute very little to a professor's research except perhaps the very bright ones, and the professor really does his job in those areas as a duty, too. I think the same thing is true in the area of physical science theory. Students are just not capable of making much of a contribution to the professor's research and reputation.

So I think that's why I would be inclined to say the natural sciences does seem like a different ball game and that I see no pressing need for radical change. There are, of course, problems. I might make one suggestion: In looking at the modes of graduate education in chemistry and physics for example, one finds two very different types of philosophy. It is evidenced by the fact that chemists will normally finish their degrees in something like four years full time study, where the



physicist will get his Ph.D. in more like six years of full time study.

What is the difference between the two programs? Well, I think it has to do with traditions and what the physics professor expects in level of competence of his student compared to what the chemistry professor expects, and I think the chemistry professor has lower sights on this one. There is probably the idea, too, that physics experimentation is more complex, takes longer to build and experiments are more difficult, but I think basically it is a question of what the physics professor expects in the way of competence from his student which admittedly in all areas is a purely arbitrary decision.

But there is another difference between chemistry and physics is that many chemists, on finishing their degree, take a year or two of post-doctoral study. Physicists generally do not for the obvious reason they have been long at it and perhaps they are tired of it. But I think physicists might consider the chemistry system in which you choose a lower level of competence, put all the students through in four years or something like it-- I am not proposing any rigid time schedule, it is not applicable, I think, to science--and then for the ones who

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are truly interested in a research career, let them take a year or two of our post-doc. I think that package is a better package than six years at one institution under one professor.

And if the physics people were to move in this direction from say a four year program, expect less in the way of competence--again, it is an arbitrary decision--we would save a lot of effort, time and money by allowing those students to self-select themselves to go on to further study as a post-doctoral student--and I emphasize "student" because I think in almost all cases post-doctorals are really students.

One other point, and this was a complaint of the students in natural sciences from the Ann Heiss survey. Students felt that their research programs were too narrow and they had limitations on interdisciplinary study. Physicists, for example, will let their students take mathematics, and that's fine; chemists will let their students take biochemistry, math or physics. But rarely are the students encouraged--and often not allowed--to broaden out into the more applied areas--the current words these days are things like "ecology" and "water resources." I believe that's good, really. I don't know.

what a degree program in water resources would mean.

I think that students should be trained as chemists, they should be given the opportunity, with flexibility in programing, to take a course or two in these applied areas if they are interested in them, but first become chemists and then after they finish, move into these other areas and take their competency in chemistry with them. It seems to me that we don't want to clutter up these applied areas with incompetent or poorly trained chemists.

Lastly, let me mention two or three medieval anachronisms that still persist in our institutions. The first one is not directly applicable to my charge, but it's a strange one, and it is the sanctity of the diploma.

Now, you know, I suppose in all our institutions the Great Seal of the university is locked up in a vault and people get these diplomas and there is all kinds of security on them and whatnot. I just think that's an anachronism. I don't want to do away with it, but we should recognize it for what it is, it is a wall decoration, particularly for Ph.D's. Perhaps in the 15th century it meant something when you couldn't write to Bologna and get the man's transcript and he carried his

diploma with him. But I think that same thing applies to our thesis, our concept of the sanctity of the thesis which, perhaps, may go back to the days before books were so readily available--and now I am limiting my remarks to the natural sciences.

I don't really see any need for a thesis as we know it. I don't see why we are faced with the problem we were at Cornell when a student wanted to put his 14 publications between the usual black-covered thesis binding and the General Committee said no. I think all he would do to satisfy me is say he had 14 publications and his professor agree with him.

One might argue, well suppose the scientific paper is not published? I would say in these days of great proliferation of scientific publications, if something is not publishable it is not worth reading.

Lastly, the other medieval anachronism that I think still persists in universities is the sanctity of the Ph.D. itself. I think at one time in the history of educational development it really meant something as far as certification goes. Nowadays I don't believe it. I think any ambitious, hard working student that wants to get a Ph.D. can do so if he plays his cards right. But I don't suppose we are going to do away with that certification anachronism because, as the Wizard of Oz said, "You don't need a brain, you need a diploma."